ΠΑΝΕΠΙΣΤΗΜΙΟ ΔΥΤΙΚΗΣ ΑΤΤΙΚΗΣ
ΣΧΟΛΗ ΕΠΑΓΓΕΛΜΑΤΩΝ ΥΓΕΙΑΣ ΚΑΙ ΠΡΟΝΟΙΑΣ
ΤΜΗΜΑ ΜΑΙΕΥΤΙΚΗΣ
ΠΡΟΗΓΜΕΝΗ ΚΑΙ ΤΕΚΜΗΡΙΩΜΕΝΗ ΜΑΙΕΥΤΙΚΗ ΦΡΟΝΤΙΔΑ

Μεταπτυχιακή Διπλωματική Εργασία

Περιγεννητικές και νεογνικές εκβάσεις με τη χρήση του καρδιοτοκογραφήματος έναντι STAN και καρδιοτοκογραφήματος

Φοιτήτρια:

Τσιλιγκερίδου Σοφία

ΑΜ: 20068

Επιβλέπουσα Καθηγήτρια:
Γουρουντή Κλεάνθη / Αναπληρώτρια Καθηγήτρια

Μέλη Τριμελούς Επιτροπής:
Λυκερίδου Αικατερίνη / Καθηγήτρια ΠΑ.Δ.Α.
Ξανθός Θεόδωρος / Καθηγητής Φυσιολογίας-Παθοφυσιολογίας ΠΑ.Δ.Α.

Αθήνα, Μάϊος, 2023

UNIVERSITY OF WEST ATTICA
FACULTY OF HEALTH & CARE SCIENCES
DEPARTMENT OF MIDWIFERY
ADVANCED & EVIDENCE BASED MIDWIFERY CARE

Diploma Thesis

Perinatal and neonatal outcomes using cardiotocography versus STAN and cardiotocography

Student name and surname:

Tsiligkeridou Sofia

Registration Number: 20068

Supervisor name and surname:

Gourounti Kleanthi / Assistant Professor

Athens, May, 2023

ΠΑΝΕΠΙΣΤΗΜΙΟ ΔΥΤΙΚΗΣ ΑΤΤΙΚΗΣ
ΣΧΟΛΗ ΕΠΑΓΓΕΛΜΑΤΩΝ ΥΓΕΙΑΣ ΚΑΙ ΠΡΟΝΟΙΑΣ
ΤΜΗΜΑ ΜΑΙΕΥΤΙΚΗΣ
ΠΡΟΗΓΜΕΝΗ ΚΑΙ ΤΕΚΜΗΡΙΩΜΕΝΗ ΜΑΙΕΥΤΙΚΗ ΦΡΟΝΤΙΔΑ

Περιγεννητικές και νεογνικές εκβάσεις με τη χρήση του καρδιοτοκογραφήματος έναντι STAN και καρδιοτοκογραφήματος

Μέλη Εξεταστικής Επιτροπής συμπεριλαμβανομένου και του Εισηγητή

Η μεταπτυχιακή διπλωματική εργασία εξετάστηκε επιτυχώς από την κάτωθι Εξεταστική Επιτροπή:

Α/α	ΟΝΟΜΑ ΕΠΩΝΥΜΟ	ΒΑΘΜΙΔΑ/ΙΔΙΟΤΗΤΑ	ΨΗΦΙΑΚΗ ΥΠΟΓΡΑΦΗ
1	ΓΟΥΡΟΥΝΤΗ ΚΛΕΑΝΘΗ	ΑΝΑΠΛΗΡΩΤΡΙΑ ΚΑΘΗΓΗΤΡΙΑ ΠΑ.Δ.Α.	Kleanthi Gourounti Digitally signed by Kleanthi Gourounti Date: 2023.05.15 12:21:08 +03'00'
2	ΛΥΚΕΡΙΔΟΥ ΑΙΚΑΤΕΡΙΝΗ	ΚΑΘΗΓΗΤΡΙΑ ΠΑ.Δ.Α.	Aikaterini Lykeridou Avramioti Digitally signed by Aikaterini Avramioti Date: 2023.07.21 00:31:58 +03'00'
3	ΞΑΝΘΟΣ ΘΕΟΔΩΡΟΣ	ΚΑΘΗΓΗΤΗΣ ΦΥΣΙΟΛΟΓΙΑΣ-ΠΑΘΟΦΥΣΙΟΛΟΓΙΑΣ ΠΑ.Δ.Α.	Theodoros Xanthos Digitally signed by Theodoros Xanthos Date: 2023.05.15 15:37:22 +03'00'

ΔΗΛΩΣΗ ΣΥΓΓΡΑΦΕΑ ΜΕΤΑΠΤΥΧΙΑΚΗΣ ΕΡΓΑΣΙΑΣ

Η κάτωθι υπογεγραμμένη Τσιλιγκερίδου Σοφία του Γεωργίου, με αριθμό μητρώου 20068 φοιτήτριας του Προγράμματος Μεταπτυχιακών Σπουδών Προηγμένη και Τεκμηριωμένη Μαιευτική Φροντίδα του Τμήματος Μαιευτικής της Σχολής Επαγγελμάτων Υγείας και Πρόνοιας του Πανεπιστημίου Δυτικής Αττικής, δηλώνω ότι: «Είμαι συγγραφέας αυτής της μεταπτυχιακής εργασίας και ότι κάθε βοήθεια την οποία είχα για την προετοιμασία της, είναι πλήρως αναγνωρισμένη και αναφέρεται στην εργασία. Επίσης, οι όποιες πηγές από τις οποίες έκανα χρήση δεδομένων, ιδεών ή λέξεων, είτε ακριβώς είτε παραφρασμένες, αναφέρονται στο σύνολό τους, με πλήρη αναφορά στους συγγραφείς, τον εκδοτικό οίκο ή το περιοδικό, συμπεριλαμβανομένων και των πηγών που ενδεχομένως χρησιμοποιήθηκαν από το διαδίκτυο. Επίσης, βεβαιώνω ότι αυτή η εργασία έχει συγγραφεί από μένα αποκλειστικά και αποτελεί προϊόν πνευματικής ιδιοκτησίας τόσο δικής μου, όσο και του Ιδρύματος.
Παράβαση της ανωτέρω ακαδημαϊκής μου ευθύνης αποτελεί ουσιώδη λόγο για την ανάκληση του πτυχίου μου».

**Επιθυμώ την απαγόρευση πρόσβασης στο πλήρες κείμενο της εργασίας μου μέχρι …… και έπειτα από αίτηση μου στη Βιβλιοθήκη και έγκριση του επιβλέποντα καθηγητή.*

Η Δηλούσα

*** Ονοματεπώνυμο /Ιδιότητα**
Τσιλιγκερίδου Σοφία / Φοιτήτρια Μεταπτυχιακών Σπουδών

Ψηφιακή Υπογραφή Επιβλέποντα
(Υπογραφή)

**** Εάν κάποιος επιθυμεί απαγόρευση πρόσβασης στην εργασία για χρονικό διάστημα 6-12 μηνών (embargo), θα πρέπει να υπογράψει ψηφιακά ο/η επιβλέπων/ουσα καθηγητής/τρια, για να γνωστοποιεί ότι είναι ενημερωμένος/η και συναινεί. Οι λόγοι χρονικού αποκλεισμού πρόσβασης περιγράφονται αναλυτικά στις πολιτικές του Ι.Α. (σελ. 6):***

https://www.uniwa.gr/wp-content/uploads/2021/01/%CE%A0%CE%BF%CE%BB%CE%B9%CF%84%CE%B9%CE%BA%CE%B5%CC%81%CF%82_%CE%99%CE%B4%CF%81%CF%85%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%BF%CF%85%CC%81_%CE%91%CF%80%CE%BF%CE%B8%CE%B5%CF%84%CE%B7%CF%81%CE%B9%CC%81%CE%BF%CF%85_final.pdf

Ευχαριστίες

Θα ήθελα να εκφράσω την ευγνωμοσύνη μου στην επιβλέπουσα καθηγήτρια μου, Κα. Γουρουντή Κλεάνθη για τη συνεργασία, την καθοδήγηση και τη βοήθεια που μου παρείχε καθ' όλη τη διάρκεια συγγραφής της διπλωματικής εργασίας.

Θα ήθελα να ευχαριστήσω από καρδίας την οικογένεια μου για την απεριόριστη υποστήριξη και κατανόηση τους.

Περιεχόμενα

Περίληψη

Εισαγωγή: Η ανάλυση της κυματομορφής ST (STAN) εισήχθη για τη βελτίωση της ερμηνείας του καρδιοτοκογραφήματος (CTG) με αποτέλεσμα τη μείωση των περιττών παρεμβάσεων και της μεταβολικής οξέωσης. **Σκοπός:** Ο σκοπός της παρούσας συστηματικής ανασκόπησης ήταν να αξιολογηθεί η επίδραση της μεθόδου STAN σε σύγκριση με το συμβατικό CTG όσον αφορά τις περιγεννητικές και νεογνικές εκβάσεις. **Μέθοδοι:** Διεξήχθη μια αναζήτηση στις ηλεκτρονικές βάσεις δεδομένων (PubMed, Cochrane, Scopus) για τον εντοπισμό τυχαιοποιημένων ελεγχόμενων δοκιμών (RCTs) στην Αγγλική γλώσσα. Στις εκβάσεις περιλαμβάνονταν οι παρεμβατικοί τοκετοί, η αιμοληψία από το τριχωτό της κεφαλής του εμβρύου (FBS), η μεταβολική οξέωση, ο περιγεννητικός και νεογνικός θάνατος, οι νεογνικές κρίσεις, η νεογνική εγκεφαλοπάθεια, η μεταφορά στη μονάδα εντατικής νοσηλείας νεογνών (NICU) και η βαθμολογία Apgar. **Αποτελέσματα:** Στην ανασκόπηση συμπεριελήφθησαν επτά RCTs. Οι δύο πρώτες RCTs έδειξαν ότι ο συνδυασμός STAN και CTG είναι καλύτερη επιλογή από τη χρήση μόνο του CTG καθώς αποδείχθηκε μείωση του ποσοστού των παρεμβατικών τοκετών λόγω εμβρυϊκής δυσφορίας και μείωση της μεταβολικής οξέωσης. Όμως οι μελέτες που ακολούθησαν δεν έδειξαν στατιστικά σημαντικές αλλαγές με τον συνδυασμό των μεθόδων, εκτός από τη μείωση του FBS. **Συμπεράσματα:** Τα ευρήματα από τις RCTs ήταν διαφορετικά και αντικρουόμενα. Οι περισσότερες μελέτες δεν αναγνώρισαν την υπεροχή του συνδυασμού των δυο μεθόδων σχετικά με τους παρεμβατικούς τοκετούς και τις νεογνικές εκβάσεις, αλλά μεταξύ των μελετών υπήρχαν πολλές μεθοδολογικές διαφορές.

Λέξεις – κλειδιά: CTG, καρδιοτοκογράφημα, STAN, ST ανάλυση κυματομορφής, εμβρυϊκό ECG, εμβρυϊκό ηλεκτροκαρδιογράφημα, παρεμβατικοί τοκετοί, μεταβολική οξέωση, αιμοληψία από το τριχωτό της κεφαλής του εμβρύου , FBS, νεογνικές εκβάσεις

Abstract

Introduction: ST waveform analysis (STAN) was introduced to improve the interpretation of cardiotocography (CTG) resulting in reduction of unnecessary interventions and metabolic acidosis. **Aim:** The aim of the present systematic review was to evaluate the effect of the STAN method compared with isolated CTG on perinatal and neonatal outcomes. **Methods:** A search of electronic databases (PubMed, Cochrane, Scopus) was conducted to identify randomized controlled trials (RCTs) in English language. Outcomes considered the operative deliveries, fetal blood sampling (FBS), metabolic acidosis, perinatal and neonatal death, neonatal seizures, neonatal encephalopathy, transfer to the neonatal intensive care unit (NICU) and Apgar score. **Results:** Seven RCTs included in the review. The first two RCTs showed that the combination of STAN and CTG is a better option than using CTG alone, because a reduction in the rate of operative deliveries due to fetal distress and a reduction in metabolic acidosis was documented. The following studies showed no statistically significant changes with the combination of methods, except from a reduction in FBS. **Conclusion:** The findings from the RCTs were different and conflicting. Most studies did not recognize the superiority of the combination in operative deliveries and neonatal outcomes but there were many methodological differences between the trials.

Keywords: CTG, cardiotocography, STAN, ST waveform analysis, fetal ECG, fetal electrocardiography, operative deliveries, metabolic acidosis, fetal blood sampling, FBS, neonatal outcomes.

ΓΕΝΙΚΟ ΜΕΡΟΣ

Background

Στα μέσα του δέκατου έβδομου ή του δέκατου όγδοου αιώνα, ανακαλύφθηκε ότι είναι δυνατό να ακουστεί ο εμβρυϊκός καρδιακός παλμός μέσα από τη μήτρα. Ωστόσο, η χρησιμότητα αυτής της ανακάλυψης στην κλινική πράξη, προτάθηκε τον δέκατο ένατο αιώνα (Alfirevic et al., 2017). Έκτοτε, η παρακολούθηση του εμβρύου χρησιμοποιήθηκε ως μέθοδος για τον προσδιορισμό της εμβρυϊκής ευημερίας και για τη μείωση της περιγεννητικής νοσηρότητας και θνησιμότητας (Fuchs et al., 2016; Stout and Cahill, 2011).

Ο εμβρυϊκός καρδιακός ρυθμός (ΕΚΡ) μπορεί να παρακολουθηθεί είτε κατά διαστήματα είτε συνεχώς. Η διαλείπουσα ακρόαση μπορεί να πραγματοποιηθεί χρησιμοποιώντας το εμβρυϊκό στηθοσκόπιο (Pinard) ή τη συσκευή Doppler χειρός. Η συνεχής παρακολούθηση μπορεί να πραγματοποιηθεί με τη χρήση του καρδιοτοκογραφήματος (ΚΤΓ) ή όπως αλλιώς ονομάζεται ηλεκτρονική παρακολούθηση εμβρύου (ΗΠΕ) (Alfirevic et al., 2017; Devane et al., 2017). Το ΚΤΓ ή ΗΠΕ εφευρέθηκε τη δεκαετία του 1960 ως εναλλακτική λύση της διαλείπουσας παρακολούθησης και χρησιμοποιήθηκε ευρέως τις δεκαετίες 1970 - 1980 (Devane et al., 2017; Brocklehurst, 2016).

Η ηλεκτρονική παρακολούθηση του εμβρύου χωρίζεται σε εξωτερική και εσωτερική. Στην εξωτερική παρακολούθηση τοποθετείται, με μια ζώνη στην κοιλία της μητέρας, ένας μορφομετατροπέας υπερήχων Doppler για την εκτίμηση του ΕΚΡ και ένας τοκομορφομετατροπέας για την εκτίμηση της δραστηριότητας της μήτρας. Στην εσωτερική παρακολούθηση είναι απαραίτητη η ρήξη εμβρυϊκών υμένων καθώς τοποθετείται ένα ηλεκτρόδιο στο τριχωτό της κεφαλής του εμβρύου για την εκτίμηση του ΕΚΡ και ένας ενδομήτριος καθετήρας πίεσης για την εκτίμηση της δραστηριότητας της μήτρας (Alfirevic et al., 2017).

Τα χαρακτηριστικά που πρέπει να αναλυθούν σε ένα ΚΤΓ για την εκτίμηση του ΕΚΡ είναι η βασική γραμμή, η μεταβλητότητα, οι επιταχύνσεις και οι επιβραδύνσεις. Πιο συγκεκριμένα:

- Βασική γραμμή είναι η μέση συχνότητα του ΕΚΡ σε ένα διάστημα 10 λεπτών και κυμαίνεται ανάμεσα στους 110-160 παλμούς ανά λεπτό. Σε περίπτωση που η βασική γραμμή του ΕΚΡ είναι >160 παλμούς ανά λεπτό διάρκειας ίσης ή

μεγαλύτερης των 10 λεπτών, ορίζεται ως ταχυκαρδία. Αντίστοιχα όταν η βασική γραμμή του ΕΚΡ είναι <110 παλμούς ανά λεπτό διάρκειας ίσης ή μεγαλύτερης των 10 λεπτών ορίζεται ως βραδυκαρδία.

- Μεταβλητότητα είναι το εύρος διακύμανσης του ΕΚΡ από την βασική γραμμή και κυμαίνεται ανάμεσα στους 5-25 παλμούς ανά λεπτό. Σε υποξία/οξέωση του κεντρικού νευρικού συστήματος, η μεταβλητότητα είναι μειωμένη.
- Επιταχύνσεις είναι η αιφνίδια αύξηση του ΕΚΡ πάνω από τη βασική γραμμή κατά 15 παλμούς ανά λεπτό διάρκειας τουλάχιστον 15 δευτερολέπτων αλλά λιγότερης των 10 λεπτών, συνήθως συμπίπτουν με τις κινήσεις του εμβρύου και είναι σημάδι καλής νευρολογικής ανταπόκρισης του χωρίς υποξία/οξέωση.
- Επιβραδύνσεις αφορούν την ελάττωση του ΕΚΡ πάνω από τη βασική γραμμή κατά 15 παλμούς ανά λεπτό διάρκειας τουλάχιστον 15 δευτερολέπτων αλλά λιγότερης των 10 λεπτών και χωρίζονται σε κατηγορίες: Πρώιμες, οι οποίες προκαλούνται από τη συμπίεση της κεφαλής του εμβρύου και δεν υποδηλώνουν εμβρυϊκή υποξία/οξέωση. Όψιμες οι οποίες προκαλούνται από τη μειωμένη αιματική ροή της μητροπλακουντιακής μονάδας. Μεταβαλλόμενες, οι οποίες οφείλονται σε παροδική συμπίεση του ομφάλιου λώρου. Παρατεταμένες, οι οποίες συνδέονται συχνά με εμβρυϊκή υποξία/μεταβολική οξέωση και απαιτούν επείγουσα παρέμβαση (Ayres-de-Campos et al., 2015).

Ο σκοπός του ΚΤΓ είναι να ανιχνεύσει τις αλλαγές στα χαρακτηριστικά του ΕΚΡ και να καθορίσει τα έμβρυα που κινδυνεύουν από ασφυξία και μπορούν να ωφεληθούν από έναν άμεσο τοκετό (Alfirevic et al., 2017; Brocklehurst, 2016). Η εμβρυϊκή ασφυξία είναι ένας συνδυασμός υποξίας, υπερκαπνίας και μεταβολικής οξέωσης και μπορεί να προκαλέσει μόνιμη νευρολογική βλάβη όπως εγκεφαλική παράλυση και υποξική ισχαιμική εγκεφαλοπάθεια ή θάνατο (Salmelin et al., 2013; Schuit et al., 2013; Carter, 1988). Παρά τον σκοπό του ΚΤΓ, η χρήση του δεν βελτίωσε την περιγεννητική θνησιμότητα ούτε τα ποσοστά εγκεφαλικής παράλυσης, αντίθετα προκάλεσε αύξηση της συχνότητας των καισαρικών τομών (ΚΤ) και των επεμβατικών κολπικών τοκετών, προσφέροντας μόνο μείωση της συχνότητας των νεογνικών κρίσεων. Το γεγονός αυτό οφείλεται στη χαμηλή ειδικότητα που έχει το ΚΤΓ σαν μέθοδος και κατ΄επέκταση στην υψηλή συχνότητα ψευδώς θετικών αποτελεσμάτων (Alfirevic et al., 2017).

Έτσι λοιπόν, κατέστη απαραίτητη η χρήση άλλων μεθόδων ως συμπληρωματικές εξετάσεις. Έχουν αναπτυχθεί αρκετές πρόσθετες τεχνολογίες όπως η εμβρυϊκή παλμική

οξυμετρία, η εμβρυϊκή διέγερση, η αιμοληψία από το τριχωτό της κεφαλής του εμβρύου (Fetal Blood Sampling - FBS) και η ανάλυση κυματομορφής ST του εμβρυϊκού ηλεκτροκαρδιογραφήματος (ΗΚΓ) (Visser and Ayres-De-Campos, 2015). Η χρήση της εμβρυϊκής οξυμετρίας δεν μείωσε το ποσοστό των ΚΤ ούτε βελτίωσε τα περιγεννητικά αποτελέσματα, σύμφωνα με μια συστηματική ανασκόπηση τεσσάρων δοκιμών (East et al., 2014). Η εμβρυϊκή διέγερση (δακτυλική διέγερση του τριχωτού της κεφαλής, διέγερση με μια λαβίδα Allis, ακουστικο-παλμική διέγερση) είναι μια εύκολη τεχνική αλλά δεν έχει αξιολογηθεί σε τυχαιοποιημένες δοκιμές και δεν μπορούν να εξαχθούν συμπεράσματα σχετικά με τα νεογνικά και περιγεννητικά αποτελέσματα (Visser and Ayres-De-Campos, 2015; Knupp et al., 2020).

Η αιμοληψία από το τριχωτό της κεφαλής του εμβρύου (FBS) είναι μια άβολη και επεμβατική διαδικασία, που απαιτεί κατάλληλο εργαστήριο και παρέχει περιοδικές πληροφορίες σχετικά με την κατάσταση οξυγόνωσης του εμβρύου (Knupp et al., 2020; Neilson, 2015). Το εμβρυϊκό ηλεκτροκαρδιογράφημα (ΗΚΓ) ή ST ανάλυση ή STAN είναι μια λιγότερο επεμβατική μέθοδος από τη μέθοδο FBS, με ευκολότερη εφαρμογή και παροχή συνεχής παρακολούθησης. Το εμβρυϊκό ΗΚΓ εισήχθη το 1992 μετά από πολλά πειράματα σε ζώα και η εισαγωγή του εφαρμόστηκε για να βελτιωθεί η ερμηνεία του ΚΤΓ. Τα ηλεκτρικά συμβάντα της καρδιάς καταγράφονται με τη μορφή κυμάτων μέσω ενός ηλεκτροδίου στο τριχωτό της κεφαλής του εμβρύου το οποίο συνδέεται με ένα ηλεκτρόδιο δέρματος στον μηρό της μητέρας σε έναν υπολογιστή που αναλύει τα σήματα και τα εμφανίζει στην οθόνη . Το κύμα P αντιπροσωπεύει τη κολπική συστολή, το σύμπλεγμα QRS την κοιλιακή συστολή και το κύμα T την επαναπόλωση κοιλίας (Visser and Ayres-De-Campos, 2015; Neilson, 2015; Vettore, 2021).

Η εμβρυϊκή υποξία σχετίζεται με αλλαγές στην κυματομορφή ST, λόγω απελευθέρωσης κατεχολαμινών, ενεργοποίησης β-αδρενεργικών υποδοχέων, γλυκογονόλυσης και μεταβολικής οξέωσης των ιστών. Οι αλλαγές αυτές μπορεί να είναι είτε αύξηση στο πλάτος του κύματος T, που ποσοτικοποιείται από την αναλογία T/QRS, είτε διφασικό τμήμα ST και σημειώνονται αυτόματα στην οθόνη δημιουργώντας ένα ST συμβάν. Υπάρχουν τρεις τύποι ST συμβάντων, η παροδική άνοδος T/QRS (διάρκειας <10 λεπτών), η άνοδος T/QRS από τη βασική γραμμή (διάρκειας ≥10 λεπτών) και το διφασικό ST (μέρος του τμήματος ST κάτω από τη βασική γραμμή). Το εμβρυϊκό ΗΚΓ αξιολογείται σε συνδυασμό με την ερμηνεία του ΚΤΓ, η οποία γίνεται σύμφωνα με την ταξινόμηση της Διεθνής Ομοσπονδίας

Γυναικολογίας και Μαιευτικής (FIGO) (Figure 1.). Με βάση τις κατευθυντηριες οδηγιες του STAN:

- Εάν το ΚΤΓ είναι φυσιολογικό, δεν χρειάζεται κάποια παρέμβαση και τα ST συμβάντα αγνοούνται.
- Εάν το ΚΤΓ είναι προθανάτιο τότε γίνεται άμεση παρέμβαση (τοκετός) ανεξάρτητα από την ύπαρξη ή όχι των ST συμβάντων.
- Εάν το ΚΤΓ είναι ενδιάμεσο ή παθολογικό τότε εκτιμάται ο τύπος και το εύρος των ST συμβάντων, όπου εάν το εύρος είναι πάνω από ένα προκαθορισμένο όριο τότε απαιτείται παρέμβαση. Η παρέμβαση ανάλογα με την περίσταση μπορεί να είναι η αντιμετώπιση μιας πιθανής αιτίας εμβρυϊκής δυσφορίας (π.χ. υπερτονία, υπόταση), η αιμοληψία από το τριχωτό της κεφαλής του εμβρύου (FBS) και ο τοκετός (Figure 2.) (Amer-Wahlin and Kwee, 2016; Amer-Wahlin et al., 2007).

Figure 1. Classification of CTG

Classification of CTG

Composed by the Danish and Norwegian reference group according to FIGO guidelines, December 2007

	Baseline heart frequency	Variability Reactivity	Decelerations
Normal CTG	• 110–150 bpm	• Accelerations • 5–25 bpm	• Early uniform decelerations • Uncomplicated variable decelerations (loss of <60 beats)
Intermediary CTG	• 100–110 bpm • 150–170 bpm • Short bradycardia episode <100 bpm for >3 min <80 bpm for >2 min	• >25 bpm (saltatory pattern) • <5 bpm >40 min	• Uncomplicated variable decelerations (loss of >60 beats)
	• A combination of 2 or several intermediary observations will result in an abnormal CTG		
Abnormal CTG	• >170 bpm • Persistent bradycardia <100 bpm for >10 min <80 bmp for >3 min (without an increasing tendency)	• <5 bpm for >60 min • Sinusoidal pattern	• Complicated variable decelerations with a duration of >60 sec • Repeated late uniform decelerations
Preterminal CTG	• Total lack of variability (<2 bpm) and reactivity with or without decelerations or bradycardia		

Source: neoventa.com

Figure 2. STAN clinical guidelines

	Intermediary CTG	Abnormal CTG	Preterminal CTG
Episodic T/QRS rise	>0.15	>0.10	Immediate delivery
Baseline T/QRS rise	>0.10	>0.05	
Biphasic ST	Three biphasic ST events	Two biphasic ST events	

*These guidelines are applicable to a term pregnancy of 36 completed gestational weeks or more and indicate situations in which intervention is required. This means calling for further expertise in assessing FHR data, alleviation of the cause(s) of fetal distress (overstimulation with oxytocin or maternal hypotension) or delivery. During the second stage of labour with active pushing, immediate operative delivery is recommended, unless spontaneous delivery is to be anticipated in the next 5–10 minutes.

Source: Amer-Wahlin et al., 2007

ΕΙΔΙΚΟ ΜΕΡΟΣ

Introduction

Electronic fetal monitoring (EFM) is a widely used method that is used to identify preventable cases of fetal harm but there is still controversy over its value in clinical practice. Cardiotocography (CTG) was first introduced in the 1960s and the purpose of this method was to detect changes of the fetal heart rate (FHR) characteristics and to determine the fetuses who were at risk of hypoxia and may benefit from an early delivery (Alfirevic et al., 2017; Brocklehurst, 2016). Intrapartum hypoxia and subsequent metabolic acidosis are related to short term complications such as admission to neonatal unit, hypoxic ischemic encephalopathy (HIE) and neonatal death or long-term implications such as cerebral palsy or learning difficulties (Salmelin et al., 2013; Schuit et al., 2013).

CTG is characterized by a high sensitivity, but it has only a limited specificity in predicting fetal hypoxia (Ayres-de-Campos et al., 2015). Specifically, a normal CTG is reassuring regarding the state of fetal oxygenation as hypoxia is generally restricted to cases with suspicious or pathological patterns. However, many fetuses with the latter patterns will not have clinically important hypoxia (Beard et al., 1971). Although the prediction of serious intrapartum fetal hypoxia and the avoidance of injury was the aim of fetal monitoring during labor, it was also associated with increased incidences of cesarean section and operative vaginal delivery (Alfirevic et al., 2017). Until the present, evidence of the benefits of continuous cardiotocographic monitoring remains inconclusive (Ayres-de-Campos et al., 2015).

To reduce such false positive cases and unnecessary medical interventions, several adjunctive technologies have been developed to further estimate fetal oxygenation, such as fetal blood sampling (FBS), fetal stimulation, pulse oximetry and ST waveform analysis of fetal electrocardiogram (ECG) (Visser and Ayres-De-Campos, 2015). FBS is an invasive procedure that requires appropriate laboratory and provides intermittent information because it detects evidence of hypoxia in peritheral tissue (Neilson., 2015). Furthermore, FBS is a demanding medical procedure that may be quite stressful for many doctors or mothers. Fetal stimulation is an easy technique but has not been evaluated in randomized trials and no conclusions can be drawn regarding neonatal and perinatal outcomes (Knupp et al., 2020). Unfortunately, other tools for fetal

surveillance, like pulse oximetry, have not been proved to be more effective (East et al., 2014).

ST waveform analysis (STAN), a relatively new method for continuous fetal monitoring, has been introduced after extensive experimental research (Rosen et al., 2005). The fetal ECG, like the adult ECG, records electrical events of the heart in form of waves. The P wave represents atrial contraction, QRS ventricular contraction and T ventricular repolarization. Information can be evaluated about the amplitude of the T wave in relation to the QRS complex (T/QRS ratio) and the shape of ST segment (Visser and Ayres-De-Campos, 2015; Neilson, 2015; Vettore, 2021). During labor, an electrode is applied to the fetal head to record and analyze the signals, since a lack of fetal oxygen produces changes in the fetal ECG waveform analysis. Fetal hypoxia is associated with changes in the ST waveform either a biphasic ST segment or an increase in the T/QRS ratio in combination with EFM abnormalities (Landman et al., 2019). Changes in the ST waveform generates ST events. The ST clinical guidelines provide a protocol for intervention based on CTG classification and the type and magnitude of the ST event (Amer-Wahlin et al., 2007).

The introduction of STAN was implemented to improve the interpretation of CTG and in turn reduce unnecessary interventions. To determine the benefits of the STAN method, many randomized controlled trials (RCTs) have been performed as well as many systematic reviews and meta-analyses. However, their outcomes were different and conflicting. Although some studies suggested that the combined methods provided several benefits over the CTG alone, including lower rate of operative deliveries, a decrease in the fetal metabolic acidosis and markedly improved neonatal outcomes, some studies failed to confirm the same outcomes. Thus, there is an indisputable need for improved methods as well as more randomized studies to evaluate fetal health during labor.

Aim

The aim of the present systematic review was to evaluate the effect of the STAN method compared with isolated CTG on perinatal and neonatal outcomes.

Methods

A systematic search of electronic databases (PubMed, Cochrane, Scopus) was performed in mid-2022 to identify studies that investigated perinatal and neonatal outcomes using CTG combined with ST waveform analysis compared to CTG. This review considered only RCTs published in the English language without restriction on the year of publication. Randomized trials that analyzed the PR interval rather than the ST segment of the fetal electrocardiogram as well as non-randomized trials were excluded. Reference lists of included articles were also used as an additional search method.

The search strategy used was “pregnant” OR “laboring women” AND “cardiotocography” OR “CTG” OR “electronic fetal monitoring” OR “EFM” OR “intrapartum fetal monitoring” AND “STAN” OR “ST analysis” OR “ST waveform analysis” OR “ST segment” OR “fetal electrocardiography” OR “fetal ECG” and related to the search in the title, abstract or keywords. Titles and abstracts were first screened to exclude apparently irrelevant studies. The full texts of the remaining articles were then reviewed to determine whether they met the inclusion criteria.

The inclusion criteria were:

• Population: laboring women at ≥34 weeks' gestation with a fetus in cephalic presentation and continuous electronic fetal monitoring during labor.

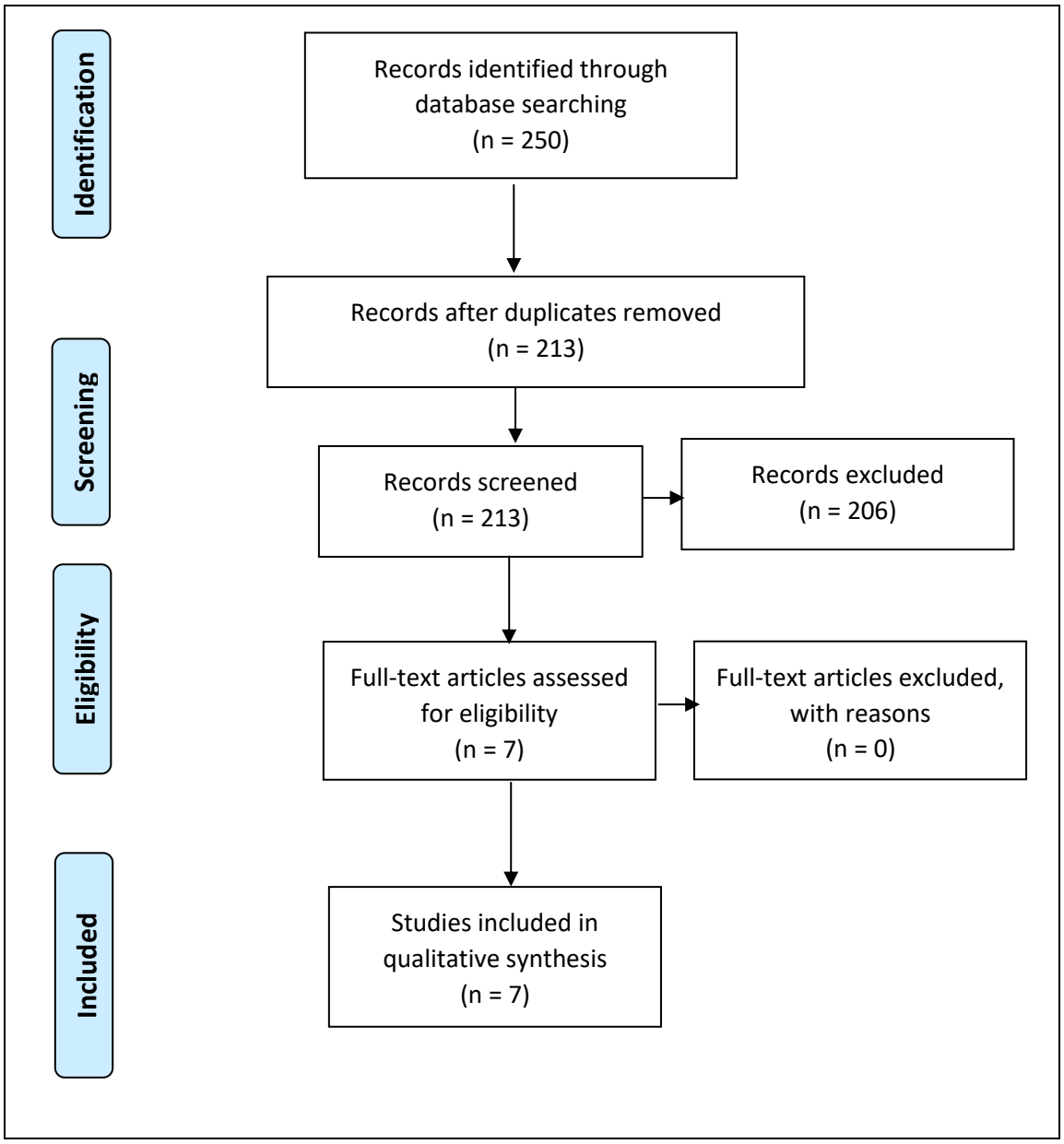
• Intervention: CTG combined with STAN

• Comparison: CTG

• Outcomes: Perinatal outcomes such as operative deliveries (cesarean delivery, instrumental vaginal delivery) and fetal blood sampling. Neonatal outcomes such as metabolic acidosis, perinatal and neonatal death, neonatal seizures, neonatal encephalopathy, transfer to the neonatal intensive care unit (NICU) and Apgar score.

The initial database search resulted in 250 articles, of which 37 were duplicates (Fig. 1). Titles and abstracts were then screened for relevance to the aim of the review. After evaluating the titles and abstracts, 206 articles were excluded because they were irrelevant to the aim of the study. Seven studies were fully reviewed and met all the inclusion criteria. Data from the seven studies were analyzed and assessed for methodological quality with CONSORT checklist.

Figure 3. Flow Chart



Results

A randomized clinical trial (Westgate et al., 1993) with pregnant women of >34 weeks' pregnancy with no known difficulties, was conducted for one year at Plymouth General Hospital in the United Kingdom. The recordings were made with the use of the HP 8040A cardiotocogram recorder (Hewlett-Packard, Boblingen, Germany) or the STAN 8801 recorder (Cinventa AB, Molndal, Sweden). During this year 2400 deliveries were included in the trial, 1212 of which were monitored with the cardiotocogram arm and 1188 were monitored with the ST waveform analysis plus cardiotocogram arm. As reported in this study 39% of the pregnancies had continuous monitoring with the use of a fetal scalp electrode, 34% had continuous external monitoring, and 28% were monitored by intermittent auscultation. It is referred that fetal blood sampling was performed in more women in the CTG arm than in the STAN arm. Also, more episodes of metabolic acidosis and low 5-minute Apgar scores were reported in the CTG arm. Regarding the operative deliveries, there was a highly significant reduction in total operative deliveries for fetal distress in the STAN arm, but there were no differences in the number of operative deliveries for failure to progress between the two arms. Additionally, even though there was no observed difference in the heart rate recordings in the first stage of labor between the two recorders, in the second stage the cardiotocogram recorder produced significantly better heart rate recordings. Taken together, the study concluded that changes in ST waveform analysis plus cardiotocogram arm can interpret the various changes in the fetal heart rate assisting in a safe delivery.

Similarly, in another trial which conducted in Sweden from 1998 to 2000 (Amer-Wahlin et al., 2001), 4966 pregnant women at more than 36 completed weeks were monitored either with cardiotocography alone or ST waveform analysis, using the STAN S21 (Neoventa Medical) recorder, combined with cardiotocography. The results showed that ST waveform analysis with CTG reduces fetal hypoxia during labor as well as the number of operative deliveries for fetal distress. Specifically, 2447 women were monitored with CTG, while 2519 were monitored with STAN. Metabolic acidosis was the first parameter considered, defined as a cord-artery blood pH of less than 7.05 and BDecf of more than 12 mmol/L (Siggaard-Andersen et al., 1971). The second parameter was the number of the operative deliveries for fetal distress and the third one was the

neonatal morbidity based on Apgar scores at 1 and 5 min and admission to NICU, while fetal blood sampling was optional in both groups. Although, statistically significant differences were not observed between the two groups regarding the Apgar score, admission to NICU or neonatal encephalopathy, there was significantly lower rate of the cases of metabolic acidosis in STAN group. In this group also, the number of operative deliveries for fetal distress was significantly lower, suggesting that ST waveform analysis combined with CTG leads to a significantly improved perinatal result.

On the contrary, a randomised trial in which 1472 women at 36 or more weeks of pregnancy were enrolled (Ojala et al., 2006) showed that there were no statistically significant superior results in the STAN group (using the same recorder STAN S21 with Amer-Wahlin et al., 2001) compared to the CTG group. The trial was conducted in Finland for one year (2003-2004) and it is reported that 733 women were included to the STAN group and 739 women to the CTG group. There were no statistically significant differences in metabolic acidosis, in neonatal outcomes, or in the rate of operative deliveries between the two groups concluding that automatic ST waveform analysis may not contribute to improvement of neonatal outcome. However, ST waveform analysis led to FBS reduction. A study conducted in French hospitals (Vayssière et al., 2007), investigated whether ST-segment analysis (with STAN S21, Neoventa Medical) along with CTG could decrease the operative deliveries in women with abnormal cardiotocography in labor. In this study, 399 out of 799 women with abnormal cardiotocography, were placed in the STAN group and 400 women in the CTG group. Neonatal outcomes did not differ between the two groups and STAN did not lead to operative delivery rate reduction (cesarean or instrumental) for nonreassuring fetal status. The authors noticed an important reduction in the number of women whose fetus had at least 1 scalp blood pH measurement during labor in the STAN group.

Considering the findings of the Dutch study (Westerhuis et al., 2010) with 5.667 women in high-risk pregnancies over the 36 weeks, it showed that although ST analysis combined with CTG decreased the metabolic acidosis, no changes in the Apgar scores and the rate of operative deliveries were observed. The women participated in this study were distributed in the index group (2.827 women) wearing a scalp electrode connected with a STAN S21 or S31 and the control group (2.840 women) wearing a scalp

electrode connected to a conventional CTG. The incidence of metabolic acidosis calculated in the extracellular fluid was lower in the STAN group, but the incidence of metabolic acidosis calculated in the blood was significantly lower in this group. Also, the need for FBS was significantly lower in the STAN group than in the CTG group. After the European studies an American study was also conducted (Belfort et al., 2015), which concluded that ST waveform analysis combined with CTG did not improve perinatal outcomes or the number of operative deliveries. This multicenter randomized trial included 11.108 women at 36 weeks (or more) with a singleton pregnancy, of whom 5576 women were assigned to the masked group where the STAN S31 device was utilized as a common electronic FHR monitor and 5532 were assigned to the open group where the STAN S31 device was displayed ECG ST-segment information. The study claimed that there was no significant difference in the neonatal and maternal outcomes except for the Apgar score of 3 or less at 5 minutes which was more frequent in the open group.

More recently, a study was conducted in Spain based on a homogeneous population, in contrast to previous studies which have included both high and low risk population with disparate inclusion criteria (Puertas et al., 2019). The population sample was women with a singleton late-term pregnancy (about 291 to 294 days) because these pregnancies were at risk for FHR alterations during labor. This randomized study included 200 women of whom 100 were enrolled to the CTG group and 100 to the STAN group (using the STAN S31, Neoventa Medical). The authors claimed that there were no differences in the number of operative deliveries, including the number of cesarean deliveries, or in neonatal outcomes between the two groups comprising of women in late-term pregnancies.

The results of the above studies are summarized in the table below.

Table 1. Methodological characteristics of included studies.

	Number of Centers	Inclusion Criteria	Sample Size	Type of Electronic Fetal Monitoring
Westgate, 1993, UK	Single center	All pregnancies of >34 weeks; with no gross fetal abnormality and with a decision to apply a scalp electrode	2.400	Internal or External
Amer-Wahlin, 2001, Sweden	Multicenter 3 centers	Laboring women; ≥36 weeks; singleton fetus; cephalic presentation; with a clinical decision of continuous internal CTG	4.966	Internal
Ojala, 2006, Finland	Single center	Laboring women; ≥36 weeks; singleton fetus; cephalic presentation; with a decision of amniotomy	1.472	Internal or External
Vayssiere, 2007, France	Multicenter 2 centers	Laboring women; ≥36 weeks; singleton fetus; cephalic presentation; with abnormal CTG or thick meconium-stained amniotic fluid	799	Internal or External (not specified)
Westerhuis, 2010, Netherlands	Multicenter 9 centers	Laboring women aged ≥18 years; ≥36 weeks; singleton fetus; cephalic presentation; high risk pregnancy; with an indication for internal EFM	5.667	Internal
Belfort, 2015, USA	Multicenter 16 centers	Laboring women; ≥36 weeks; singleton fetus; with cervical dilation of 2 to 7 cm	11.108	Internal
Puertas, 2019, Spain	Single center	Laboring women; late term pregnancy (between 291 and 294 days); singleton fetus; cephalic presentation	200	External

Table 1. (Continued).

	STAN Device	CTG Device	Classification System	Randomization
Westgate, 1993, UK	STAN 8801 (Cinventa AB)	CTG (Hewlett-Packard 8040A)	4-tier system FIGO	Original randomization using sealed envelopes
Amer-Wahlin, 2001, Sweden	STAN S21 (Neoventa Medical)	Masked STAN S21	4-tier system FIGO	Allocation by STAN software at start-up (computer-generated table of random numbers)
Ojala, 2006, Finland	STAN S21 (Neoventa Medical)	CTG (Hewlett-Packard 8030A)	4-tier system FIGO	Opaque numbered sealed envelopes (randomization code generated by a computer program in blocks of 100)
Vayssiere, 2007, France	STAN S21 (Neoventa Medical)	CTG (Hewlett-Packard 8030A)	4-tier system FIGO	Opaque numbered sealed envelopes stratified by center (dilation at randomization (centimeters)
Westerhuis, 2010, Netherlands	STAN S21 or S31 (Neoventa Medical)	Conventional FHR monitor	4-tier system FIGO	Stratified randomization by center and parity. (on a 1:1 basis through a web-based computer-generated randomization sequence with variable block size)
Belfort, 2015, USA	STAN S31 (Neoventa Medical)	Masked STAN S31	3-tier system FDA	Encrypted randomization installed on the S31 monitors (separate randomization sequence for each monitor)
Puertas, 2019, Spain	STAN S31 (Neoventa Medical)	CTG (Philips Avalon FM30)	4-tier system FIGO	Serially numbered opaque envelopes (allocation ratio 1:1)

Table 1. (Continued).

	Primary Outcomes	Secondary Outcomes
Westgate, 1993, UK	Operative delivery for fetal distress, Metabolic acidosis in extracellular fluid	FBS, Apgar score, NICU admission
Amer-Wahlin, 2001, Sweden	Metabolic acidosis in extracellular fluid	Operative delivery for fetal distress, Apgar score, NICU admission, Neonatal encephalopathy
Ojala, 2006, Finland	Neonatal acidemia (umbilical artery pH <7,10)	Operative intervention, FBS, Umbilical artery pH <7,05, Metabolic acidosis in blood
Vayssiere, 2007, France	Operative delivery for nonreassuring fetal status	Total rate of operative deliveries, FBS, Metabolic acidosis in extracellular fluid, Apgar score, NICU admission, Neonatal convulsions, Neonatal death
Westerhuis, 2010, Netherlands	Metabolic acidosis in extracellular fluid	Operative delivery, FBS, Metabolic acidosis in blood, Apgar score, Total neonatal admissions, NICU admission, Neonatal encephalopathy
Belfort, 2015, USA	Composite of neonatal outcomes	Maternal outcomes, Neonatal outcomes
Puertas, 2019, Spain	Neonatal outcome (arterial blood pH for nonreassuring fetal status)	Maternal outcome (type of delivery and indications for each type)

Table 1. (Continued).

	Results
Westgate, 1993, UK	STAN group: Significant reduction in operative deliveries for fetal distress, Trend to less FBS, Trend to less metabolic acidosis, Trend to fewer low 5-minute Apgar score
Amer-Wahlin, 2001, Sweden	STAN group: Significant reduction in operative deliveries for fetal distress, Significant reduction in metabolic acidosis, No significant differences regarding Apgar score, NICU admission, Neonatal encephalopathy
Ojala, 2006, Finland	STAN group: Significant reduction in FBS, No reduction regarding Umbilical artery Ph <7,05, Metabolic acidosis in blood, No differences regarding Neonatal acidemia, Operative intervention, Apgar score, NICU admission, Neonatal encephalopathy
Vayssiere, 2007, France	STAN group: Significant reduction in FBS, No differences regarding Operative delivery for nonreassuring fetal status, Total rate of operative deliveries, Metabolic acidosis in extracellular fluid, Apgar score, NICU admission, Neonatal convulsions, Neonatal death
Westerhuis, 2010, Netherlands	STAN group: Reduction in Metabolic acidosis in extracellular fluid, Significant reduction in Metabolic acidosis in blood, Reduction in FBS, Operative deliveries were comparable between the groups, No differences regarding Apgar score, Total neonatal admissions, NICU admission, Neonatal encephalopathy
Belfort, 2015, USA	No differences regarding Primary composite neonatal outcomes, Maternal outcomes, Secondary neonatal outcomes Increase to the frequency of the low 5-minute Apgar score in STAN group
Puertas, 2019, Spain	No statistically significant differences regarding Neonatal and Maternal outcomes between the groups

Discussion

In the current study, a systematic review was performed comparing the STAN and conventional CTG methods in terms of perinatal and neonatal outcomes. This section follows the discussion of the results from the primary studies that met our analysis inclusion criteria.

It appears that the physiology of various changes in the ST waveform of the fetal electrocardiogram, combined with heart rate recording can provide predictive value for different perinatal conditions during labor. Indeed, in the study by Westgate et al., there was a 46% reduction in the occurrence of operative deliveries for fetal distress and a trend towards less metabolic acidosis ($p = 0.09$), but this was not statistically significant. Also, fewer low 5-minute Apgar scores were reported in the group where the ST waveform was examined together with the CTG. During the study and given that it included 2400 pregnant women with high-risk pregnancies, the combination of an abnormal CTG and a progressive ST-wave elevation was associated with the group of fetuses in which metabolic acidosis was detected.The ST-wave elevation is possibly explained by glycogenolysis in the myocardium and activation of anaerobic metabolism through a wave of catecholamines, activation of adrenergic receptors, as the expected physiological response to hypoxemia (Greene et al., 1982). This change can be expressed as a ratio of T wave height to QRS height, the T/QRS ratio. The occurrence of metabolic acidosis in fetuses can lead to perinatal complications up to birth asphyxia (Low et al., 1988). In this way, the combination of ST analysis and cardiotocography during labor could lead to less severe complications and less incidences of fetal distress resulting in less need of operative deliveries. The authors highlighted that technological development of the STAN device would be necessary to identify an ST-segment depression that may be overlapped if only the T/QRS ratio is examined.

Towards this direction, the study by Amer-Wahlin et al. used a new instrument that corrected the limitations of the earlier study. The device in this study, using digital signal processing, performed automatic evaluation of ST changes through a dedicated system (Luzietti et al., 1999). It was evaluated in observational clinical studies and in this study including many women in labor (4966 women), confirming the superiority of the combination of ST-waveform analysis with the CTG compared to the CTG alone. This study analyzed cases of fetal distress and metabolic acidosis in the fetus that resulted to perinatal complications. The data confirmed that a rise in the T/QRS ratio

of the fetal ECG has been associated with fetal hypoxia and that the addition of ST wave analysis to conventional cardiotocography improved the specificity of perinatal monitoring by reducing the rate of operative deliveries and fetal distress. As in the study by Westgate et al., metabolic acidosis at birth was lower in the STAN group, except that in this study the reduction was statistically significant due to both the development of the device and the larger sample of women analyzed. The new device was automated and had the capability to analyze and record all waveform changes, including biphasic ST segment. Another difference between these two studies concerned the protocol as in the Westgate et al. study, intervention was carried out if the T/QRS ratio exceeds a certain level. While in the Amer-Wahlin et al. study, the intervention was carried out if a rise in the T/QRS ratio or biphasic ST segment occurred, in combination with an abnormal or nonreassuring CTG.

The first studies (Westgate et al., 1993; Amer-Wahlin et al., 2001) showed that the combination of fetal ECG with CTG is a better option than using CTG alone, because a reduction in the rate of operative deliveries due to fetal distress and a reduction in metabolic acidosis was documented. Unlike the studies mentioned above, the Finnish trial (Ojala et al., 2006) recognized only one positive result regarding the needs of obtaining fetal blood (FBS), which were significantly lower in the STAN method. Therefore, the STAN method in this study significantly decreased the need for FBS but there were no statistically significant superior results in the incidence of metabolic acidosis or operative deliveries. The studies that followed had similar results with the Finnish trial. For example, the French trial (Vayssiere et al., 2007) that included women with abnormal CTG showed a significant reduction in FBS and no difference in terms of operative deliveries or metabolic acidosis. The Dutch trial (Westerhuis et al., 2010) also showed a reduction in FBS and no difference in operative deliveries with the STAN method but there was a significant reduction in metabolic acidosis calculated in blood and a reduction (not significant) in metabolic acidosis calculated in extracellular fluid.

In the U.S. trial (Belfort et al., 2015) where ST-wave analysis was combined with continuous fetal monitoring by CTG, no statistically significant changes were found to show superiority of the combination of methods. The authors gave possible explanations for these differences between the U.S. trial results and those of European results. Some of these explanations were the Hawthorne effect (the tendency of some to perform better when monitored) resulting in improved fetal heart rate patterns

interpretation and the fact that the operative vaginal deliveries and the use of FBS was more common in Europe. Recently, a new RCT was conducted offering information about homogeneous population. In this trial included women with late-term pregnancy, a sample of the at-risk population in which the risk was homogeneous in contrast to the previous trials (Puertas et al., 2019). The results of this study showed no change or statistically significant benefit from the combination of methods in relation to cardiotocography alone in terms of perinatal or neonatal complications.

Many randomized controlled trials (RCTs) and systematic reviews have been performed but their outcomes were different and conflicting. The methodological differences between the studies can explain these findings. For example, the Finnish trial was used a different base deficit (BD) algorithm from the others RCTs (Ojala et al., 2006). In all studies metabolic acidosis was defined as an umbilical cord artery blood pH < 7.05 and a BD in the extracellular fluid (BD_{ecf}) > 12.0 mmol/L except the Finnish trial, in which BD was calculated in blood (BD_{blood}) and this led to a falsely elevated rate of metabolic acidosis (Olofsson et al., 2014). The US trial was used a three-category CTG classification (FDA guidelines) in contrast to the European trials which used four-category CTG classification (FIGO guidelines), and this affected the clinical behavior (Belfort et al., 2015; Amer-Wahlin and Kwee, 2016; Xodo et al., 2017). Another important difference is that in French RCT included women with abnormal CTG, which is a violation of STAN clinical guidelines as alerts for changes in the ST segment occur when the fetus is still well oxygenated (Olofsson et al.,2014; Vayssiere et al.,2007).

It is evident that apart from the first two studies (Westgate et al., 1993; Amer-Wahlin et al., 2001), the other studies included in the present paper showed no significant differences between the use of STAN method combined with CTG and the CTG alone. A meta-analysis comparing STAN method with CTG by Blix et al., 2016, showed that the STAN surveillance of the fetus can lead to less metabolic acidosis and less need for FBS. Another review and meta-analysis by Saccone et al., 2016, highlighted that STAN does not offer a better clinical choice when combined with CTG as it reduced perinatal outcomes and operative delivery rates in the same way the CTG did alone. One recent meta-analysis by Al Wattar et al., 2021 collected data from the literature and compared studies based on the different fetal surveillance methods. Among them, STAN method

and the combination with CTG were assessed for perinatal outcomes and no significant differences were evident.

This paper contains a recent and thorough review of the existing data and literature studies on the STAN method combined to CTG when compared to CTG alone. Overall, the combination of the two methods does not seem to add any further benefit in perinatal outcomes. The only possible benefit is shown by some studies pointing out that there is less need for FBS when the combination is used.

Conclusions

Seven studies were included in the present paper after a detailed review of the literature to compare fetal monitoring methods about perinatal and neonatal outcomes. The methods compared were fetal electrocardiography with ST-wave analysis and cardiotocography, combined to isolated cardiotocography. Most studies did not recognize the superiority of the combination in operative deliveries and neonatal outcomes. Cardiotocography is an essential method of monitoring the fetus with positive results. Analysis by STAN method is also a good choice but requires training in recognizing and interpreting results. Both methods can be combined with fetal blood sampling when deemed necessary to identify complications of hypoxemia or metabolic acidosis. Overall, both methods are used in clinical practice with positive results, but their combination is controversial regarding the benefit of perinatal or neonatal outcomes.

References

Alfirevic, Z., Gyte, G. M., Cuthbert, A., & Devane, D. (2017). Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour. *Cochrane database of systematic reviews*, (2).

Al Wattar, B. H., Honess, E., Bunnewell, S., Welton, N. J., Quenby, S., Khan, K. S., ... & Thangaratinam, S. (2021). Effectiveness of intrapartum fetal surveillance to improve maternal and neonatal outcomes: a systematic review and network meta-analysis. *CMAJ*, *193*(14), E468-E477.

Amer-Wahlin, I., Arulkumaran, S., Hagberg, H., Maršál, K., & Visser, G. H. A. (2007). Fetal electrocardiogram: ST waveform analysis in intrapartum surveillance. *BJOG: An International Journal of Obstetrics & Gynaecology*, 114(10), 1191-1193.

Amer-Wahlin, I., Hellsten, C., Noren, H., Hagberg, H., Herbst, A., Kjellmer, I., ... & Marsal, K. (2001). Cardiotocography only versus cardiotocography plus ST analysis of fetal electrocardiogram for intrapartum fetal monitoring: a Swedish randomised controlled trial. *The Lancet*, *358*(9281), 534-538.

Amer-Wahlin I, Kwee A. Combined cardiotocographic and ST event analysis: A review. Best Practice and Research: *Clinical Obstetrics and Gynaecology*. 2016 Jan 1; 30:48–61.

Ayres-de-Campos, D., Spong, C. Y., Chandraharan, E., & FIGO Intrapartum Fetal Monitoring Expert Consensus Panel. (2015). FIGO consensus guidelines on intrapartum fetal monitoring: Cardiotocography. *International Journal of Gynecology & Obstetrics*, *131*(1), 13-24.

Beard, R. W., Filshie, G. M., Knight, C. A., & Roberts, G. M. (1971). The significance of the changes in the continuous fetal heart rate in the first stage of labour. *BJOG: An International Journal of Obstetrics & Gynaecology*, 78(10), 865-881.

Belfort, M. A., Saade, G. R., Thom, E., Blackwell, S. C., Reddy, U. M., Thorp Jr, J. M., ... & VanDorsten, J. P. (2015). A randomized trial of intrapartum fetal ECG ST-segment analysis. *New England Journal of Medicine*, *373*(7), 632-641.

Blix, E., Brurberg, K. G., Reierth, E., Reinar, L. M., & Øian, P. (2016). ST waveform analysis versus cardiotocography alone for intrapartum fetal monitoring: a systematic

review and meta-analysis of randomized trials. *Acta obstetricia et gynecologica Scandinavica*, *95*(1), 16-27.

Brocklehurst P. A study of an intelligent system to support decision making in the management of labour using the cardiotocograph - the INFANT study protocol. *BMC Pregnancy and Childbirth*. 2016 Jan 20;16(1).

Carter M.C. Fetal monitoring. *Journal of Biomedical Engineering*. 1988 Nov 1;10(6):527-32.

Devane D., Lalor J.G., Daly S., Mcguire W., Cuthbert A., Smith V. Cardiotocography versus intermittent auscultation of fetal heart on admission to labour ward for assessment of fetal wellbeing. Vol. 2017, *Cochrane Database of Systematic Reviews*. John Wiley and Sons Ltd; 2017.

East C.E., Begg L., Colditz P.B., Lau R. Fetal pulse oximetry for fetal assessment in labour. Vol. 2014, *Cochrane Database of Systematic Reviews*. John Wiley and Sons Ltd; 2014.

Fuchs T., Grobelak K.., Pomorski M, Zimmer M. Fetal heart rate monitoring using maternal abdominal surface electrodes in third trimester: Can we obtain additional information other than CTG trace? *Advances in Clinical and Experimental Medicine*. 2016 Mar 1;25(2):309-16.

Greene, K. R., Dawes, G. S., Lilja, H., & Rosén, K. G. (1982). Changes in the ST waveform of the fetal lamb electrocardiogram with hypoxemia. *American Journal of Obstetrics and Gynecology*, 144(8), 950-958.

Knupp RJ, Andrews WW, Tita ATN. The future of electronic fetal monitoring. Vol. 67, Best Practice and Research: *Clinical Obstetrics and Gynaecology*. Bailliere Tindall Ltd; 2020. p. 44–52.

Landman AJEMC, Immink-Duijker ST, Mulder EJH, Koster MPH, Xodo S, Visser GHA, et al. Significant reduction in umbilical artery metabolic acidosis after implementation of intrapartum ST waveform analysis of the fetal electrocardiogram. *American Journal of Obstetrics and Gynecology.* 2019 Jul 1;221(1):63. e1-63. e13.

Low, J. A. (1988). The role of blood gas and acid-base assessment in the diagnosis of intrapartum fetal asphyxia. *American Journal of Obstetrics and Gynecology*, *159*(5), 1235-1240.

Luzietti, R., Erkkola, R., Hasbargen, U., Mattsson, L. Å., Thoulon, J. M., & Rosén, K. G. (1999). European community multi-center trial "fetal ECG analysis during labor": ST plus CTG analysis.

Neilson JP. Fetal electrocardiogram (ECG) for fetal monitoring during labour. Vol. 2015, *Cochrane Database of Systematic Reviews*. John Wiley and Sons Ltd; 2015.

Ojala, K., Vääräsmäki, M., Mäkikallio, K., Valkama, M., & Tekay, A. (2006). A comparison of intrapartum automated fetal electrocardiography and conventional cardiotocography—a randomised controlled study. *BJOG: an international journal of obstetrics & gynaecology*, *113*(4), 419-423.

Olofsson P, Ayres-De-Campos D, Kessler J, Tendal B, Yli BM, Devoe L. A critical appraisal of the evidence for using cardiotocography plus ECG ST interval analysis for fetal surveillance in labor. Part I: The randomized controlled trials. Vol. 93, Acta *Obstetricia et Gynecologica Scandinavica.* Wiley-Blackwell Publishing Ltd; 2014. p. 556–68.

Puertas, A., Góngora, J., Valverde, M., Revelles, L., Manzanares, S., & Carrillo, M. P. (2019). Cardiotocography alone vs. cardiotocography with ST segment analysis for intrapartum fetal monitoring in women with late-term pregnancy. A randomized controlled trial. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, *234*, 213-217.

Rosen, K. G. (2005). Fetal electrocardiogram waveform analysis in labour. *Current Opinion in Obstetrics and Gynecology*, *17*(2), 147-150.

Saccone, G., Schuit, E., Amer-Wåhlin, I., Xodo, S., & Berghella, V. (2016). Electrocardiogram ST analysis during labor: a systematic review and meta-analysis of randomized controlled trials. *Obstetrics & Gynecology*, *127*(1), 127-135.

Salmelin A, Wiklund I, Bottinga R, Brorsson B, Ekman-Ordeberg G, Grimfors EE, et al. Fetal monitoring with computerized ST analysis during labor: A systematic review

and meta-analysis. Vol. 92, *Acta Obstetricia et Gynecologica Scandinavica*. 2013. p. 28–39.

Schuit E, Amer-Wahlin I, Ojala K, Vayssière C, Westerhuis MEMH, Maršál K, et al. Effectiveness of electronic fetal monitoring with additional ST analysis in vertex singleton pregnancies at >36 weeks of gestation: An individual participant data metaanalysis. *American Journal of Obstetrics and Gynecology*. 2013;208(3): 187.e1-187.e13.

Siggaard-Andersen, O. (1971). An acid-base chart for arterial blood with normal and pathophysiological reference areas. *Scandinavian journal of clinical and laboratory investigation*, *27*(3), 239-245.

Stout MJ, Cahill AG. Electronic Feal Monitoring: Past, Present and Future. Vol.38, *Clinics in Perinatology*. 2011.p.127-42.

Vayssière, C., David, E., Meyer, N., Haberstich, R., Sebahoun, V., Roth, E., ... & Langer, B. (2007). A French randomized controlled trial of ST-segment analysis in a population with abnormal cardiotocograms during labor. *American journal of obstetrics and gynecology*, *197*(3), 299-e1.

Vettore M, Straface G, Tortora D, Parotto M, Greco P, Ugwumadu A, et al. Fetal ST baseline T/QRS rise in normal CTG does not predict neonatal acidemia. *Journal of Maternal-Fetal and Neonatal Medicine.* 2021;34(16):2666–71.

Visser GH, Ayres-De-Campos D. FIGO consensus guidelines on intrapartum fetal monitoring: Adjunctive technologies. *International Journal of Gynecology and Obstetrics.* 2015 Oct 1;131(1):25–9.

Westerhuis, M. E., Visser, G. H., Moons, K. G., Van Beek, E., Benders, M. J., Bijvoet, S. M., ... & Kwee, A. (2010). Cardiotocography plus ST analysis of fetal electrocardiogram compared with cardiotocography only for intrapartum monitoring: a randomized controlled trial. *Obstetrics & Gynecology*, *115*(6), 1173-1180.

Westgate, J., Harris, M., Curnow, J. S., & Greene, K. R. (1993). Plymouth randomized trial of cardiotocogram only versus ST waveform plus cardiotocogram for intrapartum monitoring in 2400 cases. *American journal of obstetrics and gynecology*, *169*(5), 1151-1160.

Xodo S, Saccone G, Schuit E, Amer-Wahlin I, Berghella V. Why STAN might not be dead. *Journal of Maternal-Fetal and Neonatal Medicine.* 2017 Oct 2;30(19):2306–8.